Chapter title: The Spatial Languages of Virtual Production: Critiquing Softwarization with Aesthetic Analysis

Author: Dr Tom Livingstone, University of the West of England, Bristol (UWE)

Author bio (100 words): Dr Tom Livingstone is a Research Fellow at The University of the West of England (UWE) working within MyWorld, a creative R&D programme driving industry expansion and innovation in the south west of England. His research focuses on emergent media with a particular interest in the impact of game engines on visual culture. He has published widely on film and digital media and his first book *Hybrid Images and the Vanishing Point of Digital Visual Effects* will be published by Edinburgh University Press.

Abstract

The chapter analyses the emergent practice of virtual production and the generation of in-camera visual effects (ICVFX), a process currently dominated by Unreal Engine. It will argue that the software functionality of Unreal Engine and the logistics of virtual production have aesthetic correlates within the images they produce, specifically in the form of a stylised spatial language.

Adopting the periodizing framework laid out by Scott Higgins in his work on Technicolor (2007) this chapter will compare the brief history of virtual production, with the aesthetic evolution of Technicolor and draw parallels between the relationship between the emergent colour film technology and its aesthetic affordances and the way in which virtual production and ICVFX afford a particular stylisation of space on screen.

Adopting a broad perspective and comparative methodology to the chapter will develop a granular picture of the relationship between Unreal Engine's management of multiple spaces (3D, physical, cinematographic) and the spatial aesthetics of the images it produces. The

chapter will draw on the media-epistemological work of Vilem Flusser and Wendy H. K. Chun to establish the stakes of such an analysis and point towards the epistemic ramifications implicit in softwarization. Specifically: the naturalisation of the aesthetic languages associated with creative software (such as the spatial language of Unreal-enabled ICVFX) leads to the embedding of the software's technical defaults and functional parameters within creative practice and visual experience more broadly. Teasing out the aesthetic through-lines of a range of ICVFX-reliant productions the chapter will highlight how the cross-sector integration of VP entails an inflection of the spatial languages of screen culture. The chapter closes with a call to establish more avenues wherein a critique of softwarization and its wider ramifications can proceed via aesthetic analysis.

Introduction

In Episode 5 of Netflix's 2022 series *1899*, two key protagonists—Maura (Emily Beecham) and Eyk (Andreas Pietschmann)—travel from the confines of a ship's cabin, down a vertical shaft hidden beneath a bunk, through a small tunnel lined with dark black tiles and out a portal into an entirely different landscape altogether. Finding themselves in a forest at night, the pair stumble upon a burned-out house. They enter and start exploring its rooms. The spaces they move through dilate from cramped to open to cramped again. The relationship between the spaces, between the cabin and the shaft, the tunnel and the forest, the forest and the burned-out interiors become increasingly "discorrelated," as Shane Denson has it from any sense of contiguous three-dimensional space (Denson, 2020). The spatial discorrelation of the sequence is underlined by a few lines of dialogue from Eyk: "This is impossible . . . We're on a ship. How does a whole landscape fit inside a ship?" Maura replies "This isn't the only one." Denson's concept of "discorrelation" wrestles with the aesthetic and epistemological fallout of the transition away from a cinematic media regime, characterised by a correlation between embodied perception and the spatial and temporal landscapes of visual media, towards to a digital or post-cinematic media regime wherein new forms of imagery give rise to new affective registers and multiple landscapes can be squeezed inside a

ship. This chapter will expand on this concept of discorrelation and explore not only *how* this spatial effect is achieved, but ask what the broader implications of spatial effects such as this might be.

The scene harks back to a similar transition that Maura made from the ship, via a portal to a vast snowy mountain-scape. Likewise, it anticipates the show's final provocation: not only are infinitely vast spaces hidden inside very, very small ones, but all the spaces featured in the show—including a seascape containing hundreds of wrecked cruise liners, each holding whole landscapes inside them—fit within a single simulation. The sequence also exemplifies the way in which these conjunctions of seemingly discontinuous space are represented. They are, both within the narrative logic of the "simulation" and the spatial language of the series, treated totally modularly. There is no settled map of their interconnections, instead their conjunctions are reprogrammable. They do not intersect, or meld into each other, but rather are interconnected by and accessed via obscure routes and spatially illogical portals. They are not spaces, so much as re-configurable environments.

Within the narrative, the paradoxically adjacent environments that the characters' move through are reconfigured according to a distant inaccessible logic of "simulation." The phenomenological coherence of their movement from ship to tunnel to vast open landscape is the result of a simulation that is being run in some other place (and at some other time). This fictional conceit is not so far from the actual conditions of production. As I will demonstrate across this chapter, the phenomenological coherence of onscreen spaces within the show, its spatial language, is an affordance of an emergent film production practice—virtual production (VP) and In-Camera Visual Effects (ICVFX)—and its core software, Unreal Engine. Going further, I'll suggest that the spatial language of *1899* emblematizes broader dynamics in cultural production. Taking a cue from Whissel's work on "digital effects emblems" (Whissel, 2014), and supported by Denson's work on post-cinematic "discorrelation" (Denson, 2020) I read the onscreen spaces of *1899* as "site[s] of intense signification that gives stunning (and sometimes) allegorical expression to a film's key themes, anxieties and conceptual obsession" (Whissel, 2014, p. 6). The re-configurability of environments within the show, and the dependence of the characters' embodied experience on a higher-order process of computation and technical mediation, exemplifies new forms of spatial representation emerging within the process of virtual production and gives expression to a connected set of questions concerning the role of software in the articulation of space.

This chapter takes *1899*'s narrative and practical reconfiguration of 3D environments and modularisation of space both as an expression of a new software-dependent production practice and a quintessential example of the ongoing process of softwarization as it is occurring within the creative industries and beyond.

There are two factors that give this emblematization of emerging relations between software and space a degree of urgency. First, the rapid emergence and newfound ubiquity of virtual production and ICVFX, along with its core software Unreal Engine, are driven by the inter-related factors of lockdown conditions of the pandemic and an intense cycle of investment in virtual production technologies across the globe (Bennet et al. 2021). Secondly, with this dominance of a new technical process within the realm of visual production comes the possibility of its passing what Zeilinski terms a "vanishing point" (Zeilinski 1999, 183). Here, a visual medium, such as photography, moving images or broadcast television, along with their technical and ideological parameters, become naturalised within popular visual experience. As a result, they take on what Doane termed, in the context of cinema's standardisation of the flow of time, a "knowledge effect" (Doane 2002). Through this media-epistemic lens I suggest that the spatial aesthetics associated with virtual production articulate or refract not only the underlying discorrelation of media forms from prior perceptual and epistemological norms, but also a wider socio-cultural relationship between software and space. This wider dynamic can be accessed and unpicked through close attention to the spatial languages that emerge alongside the rapid adoption of the virtual production toolkit.

To build an analytical framework with which to approach virtual production aesthetics, I will initially offer a brief outline of the practical and technical challenges involved in the process itself. This will foreground the software-dependency of the process and demonstrate the degree to which the management of the physical space of production, the virtual spaces of the digital environments and the onscreen spatial aesthetics of the final frame are contingent upon the core functionality of the Unreal Engine. Freedman writes in his work on game engines that they "mediate between data and embodiment" (Freeman 2020, 170). Likewise, Chun's seminal discussion of software uses a Marxian inversion to term software a "supersensible sensible thing," that is, an abstract thing whose operations determine our material sensibilities (Chun 2011). Within virtual production, the generation of our embodied and sensible experiences of space is wholly mediated by a software architecture that, despite

being geared towards aligning and synchronizing physical spaces and digital environments, remains intangible within those spaces.

Having outlined the logistical intricacies of the process, I will discuss the aesthetic tropes and signatures that the technical process throws up. In order to reach beyond the obvious problems of "hiding the seam" between physical space and digital environment, I instead draw an analogy between virtual production and the aesthetics of another disruptive visual media technology: Technicolor. This analogy will cement the idea that the aesthetic ramifications of emergent technologies have long tails of influence, significant to epistemic frameworks and representational politics, which will help feed into my overall discussion of softwarization. Additionally, the analogy with Technicolor will help periodize and historicize the brief history of virtual production and ICVFX aesthetics in a manner that enables final frame analysis. Armed with these analytical strategies, this chapter will conclude by drawing connections between VP practices and the softwarization of spatial experience taking place beyond visual culture. This will provide a horizon for an examination of Unreal Engine's influence of onscreen spatial aesthetics and feed back into the way in which we can detect and critique the spatial language of virtual production with final frame analysis.

INTRODUCING VIRTUAL PRODUCTION AND IN-CAMERA VFX

Virtual production and In-Camera VFX are a rapidly expanding area of film and television production in which a pre-built digital environment is rendered in real-time within an LED volume built on a sound-stage. A high-end LED volume is made up of many hundreds of individual LED panels essentially providing an enormous screen that wraps around the production space, on which can be displayed computer-generated imagery. Cameras are then motion-tracked and tethered to virtual cameras within the digital environment so that actors can perform within the LED volume surrounded (and lit) by a pre-rendered environment. When the physical camera moves in front of the actor, the digital background adjusts accordingly, to the appearance of a stable and integrated physical 3D environment, when in actual fact the camera is pointed at a performer standing in front of a huge TV. The images captured in-camera do away with a great deal of the post-production pipeline. Unlike with green screen capture and digital compositing, the spatial parallax between camera, actor and background is accounted for via motion tracking and real-time rendering. Again, in an improvement to traditional green-screen shooting and post-production manipulation, colour grading and the integration of live-action footage and digital environments occurs within the

volume. An early iteration of the process exemplifies one of its chief affordances, in the 2014 film *Gravity* and LED wall was used to solve the problem of how to show the earth reflected on the curved visors of the astronauts. Rather than taking on the incredibly complex task of compositing the earth over the recorded performances, the actors performed in front of an LED wall. The specular highlights and reflections required to sell the image of astronauts stranded high above earth, were all generated by the LED screens and the objects placed in front of them. Lastly, the digital environments are dynamic, so environmental effects and background action can be rendered on the wall and captured in-camera.

The affordances of virtual production are wide ranging. However, for the purposes of this chapter, I will focus specifically on how the process manages physical and digital space in order to capture finished, spatially contiguous, perspectivally legible images in-camera. Here, the use of an LED wall supersedes the role of the blue or green screen (and in turn the role of the rear-projection background or Schüfftan process) for generating the illusion of action taking place in an environment beyond the soundstage. But whereas green-screen processes typically involve capturing the live-action image, compositing it into a digital environment (in Nuke, for example), and rendering the final image offline, virtual production surrounds the live-action performance with the digital environment. This presents several large logistical problems, specifically the computational challenge of rendering the dynamic background in real-time and the spatial problem of maintaining a coherent parallax between the camera, the actors and props in physical space and the environmental assets in digital space. In the majority of cases, a frustrum is projected on the wall delineating the camera's view of the digital background and what is rendered in real time is only what the camera can see. As can be seen in a variety of behind-the-scenes images, this presence of the frustrum on the wall creates a scrambled sense of 3D space *for every perspective apart from that of the camera*. The frustrum ensures the overlap and continuity between physical space and digital environments, whilst also de-limiting the computational cost of real-time rendering. As such, I take it as the most palpable indicator of how the physical space of production is given over to the functionality of the Unreal Engine software, with its computational parameters and technical defaults (as well as its array of visual signatures and aesthetic determinants which I'll discuss in more depth shortly).

In a traditional VFX production pipeline, creative softwares are most instrumental in post-production processes that manipulate the image captured in-camera in order to generate a

hybrid one. By contrast, virtual production makes creative softwares—specifically Unreal Engine and its ecosystem of APIs—integral to the moment of cinematographic capture. What is more, Unreal's stratospheric rise within film and television production culture represents an acute and acutely influential moment of softwarization.

What makes it a particularly interesting case is the dominance that Unreal Engine has within the virtual production space. There is already a rich body of literature arguing that game engines are undergoing a process of platformization (Jungherr and Schlarb 2022). Suffice it to say that this single piece of software – nominally free to download and accessible for use by anyone from hobbyist to independent production to global mega-studio – is the bottleneck for a significant segment of visual culture. More importantly, as the bottleneck for the highly capitalised virtual production sector, Unreal Engine is also likely to set the parameters for and the roadmap of virtual production as an aesthetic practice. Hence, my project of identifying the spatial aesthetics of virtual production and critiquing it as a particular facet of softwarization takes place within the context of a ticking clock, specifically the ongoing dominance and naturalisation of those aesthetics which will before long sediment themselves into the normative frame of our screen experiences and wider perceptual habits.

ANALYSING VIRTUAL PRODUCTION AND IN-CAMERA VFX

Within this context of industrial dominance, the question remains, what does virtual production look like? Is it possible to tell the difference between a sequence generated within a traditional VFX pipeline, with software becoming instrumental after the camera rolls, and a VP pipeline where software is integral to what is captured in camera. To build a useful critical framework for examining the aesthetics of virtual production, I will draw from the work of Scott Higgins, specifically his monograph *Harnessing the Technicolor Rainbow: Color Design in the 1930s* (Higgins 2007).

My justification for adopting Higgins' historical-stylistic paradigm is principally drawn from the richness of the analogy between Technicolor and Unreal Engine. Technicolor's emergence within a heterogenous market of colour film technologies and subsequent dominance of colour film technique and culture, offers an interesting parallel to Unreal's early utility within a variety of VFX pipelines, and its subsequent dominance over virtual production. Additionally, the long tail of Technicolor's influence within and beyond screen culture aids speculation about the distant horizon of Unreal Engine's influence. Technicolor's

transformation from a brand-name to an adjective occurred through its process of industrial domination. Likewise, Technicolor's representational politics and the racializing impact of subsequent colour film systems genealogically linked to Technicolor's three strip system which extend all the way into the digital age (Lewis 2019) and what Joy Buolamwini defines as the "coded gaze" (Buolamwini 2020). This is a necessary reminder of the political and epistemological stakes bound up within visual cultures coalescing around particular technological hegemonies.

At a more granular level, the aesthetics associated with Technicolor were strongly influenced by the figure of Natalie Kalmus who served as "Color Consultant" on all Technicolor films produced between 1934 and 1949, the era of Technicolor's arrival at unassailability. Whilst there is no single person embodying Unreal Engine's techno-cultural influence within the contemporary production sphere, each virtual production is enabled by a suite of specialised software engineers and digital artists stationed at what has previously been referred to as the "Brain Bar."[1] Whilst not adopting a proscriptive attitude towards any given production in the fashion of Natalie Kalmus—who described herself as "ringmaster of the rainbow" (Higgins 2007)—the Brain Bar can nevertheless be conceived of as arbiters of what can and can't be achieved within virtual production, and how tight the bottleneck of Unreal Engine will be over the aesthetic affordances of any given film or TV show. And as a result, to be discussed shortly, virtual production that doesn't have access to specialised Unreal Developers tend to encounter similar obstacles in their spatial aesthetics. This cluster of shared problems stems from Unreal Engine's functionality and the requirement that productions tailor their spatial aesthetics to what VP can achieve, rather than the other way around.

Waiting to be resolved in this analogy is the fact that Higgins' framework focusses on colour design, while my proposed object of aesthetic analysis is the spatial language of virtual production. Early films shot with Technicolor responded to the technical restraints and affordances of the Technicolor's three strip process. I propose that an overview of the brief history of virtual production uncovers aesthetic tropes that likewise respond to the specific technical affordances and restraints of the process and its core software, Unreal Engine. The utility in historicizing stylistic responses to technical restraints lies in the fact that it can give

[1] For a full breakdown of the roles and skillsets of the Brain Bar present within a VP set-up, see https://www.youtube.com/watch?v=fkHdZl4z-Jk

a glimpse of the technical and pragmatic origins of culturally significant aesthetic tropes. This is certainly the case with Higgins' core thesis: Technicolor, a new production technology aggressively entering the market, progressed through three stylistic modes—demonstrative, restrained and assertive—each characterised by a particular mode of colour design (Higgins 2007, 39-46).

Dealing with these modes in turn: the "demonstrative" mode is characterised by an amplification of the system's technical tendency to capture and project red in rich and vivid detail: hence early films *La Cucaracha* (1934) and *Becky Sharp* (1935) being organised around high contrast compositions, red-daubed military uniforms, and plenty of lipstick. The "restrained" set the standards for naturalism within colour cinematography, via an emphasis not only on location shooting in *A Star is Born* (1937) but a subtle language of mid-tones and subdued temperatures, conforming the new affordances of colour cinematography to a pre-established set of genre expectations. Lastly, the "assertive" mode is exemplified, in Higgins' argument, by *Gone With The Wind* (1939) which, five years after the commercial breakthrough of Technicolor, integrates these dual affordances of the three strip colour system (to spectacle and naturalism) to create a narrative that makes both spectacular and naturalistic use of colour. The "assertive" mode instantiates a new language of expressivity in colour design, which has informed our experience of screen colour and what Richard Misek calls "chromatic cinema" ever since (Misek 2010).

Analogous to Higgins' sketch of the evolution of colour design and its responsiveness to the technical affordnaces of Technicolor's three-strip system, the aesthetics of on-screen spaces in shows such as *1899* are a response to the technical affordances and limitations of virtual production and the software that runs it. Rehearsing the various articulations of space that take place in virtual production's "demonstrative" mode, noting how these affordances are tempered in the "restrained" mode, and then re-amplified and normalised within an "integrated" stylisation of on-screen space, can equip us with a springboard with which to glimpse the future of virtual production and the potential consequences of such significant investment and industry adoption upon our experiences of space on-screen (and off).

In order to capture virtual production in its most raw demonstrative mode it is worth looking beyond the highly capitalised productions pioneering the technique, not least because those early productions were still heavily reliant on residual (post-production) VFX pipelines and

therefore don't necessarily offer the most discrete example of virtual production aesthetics. Instead, it's useful to look at some of the tech demos that smaller production companies put out in the wake of *The Mandalorian'*s success. A range of smaller companies entered the market space opened up by the R&D of *The Mandalorian* and the release by Epic of its *Virtual Production Field Guide* in 2019. In turning to these tech demos my aim is to do two things: to see how notions of the modularity of spaces and re-programmability of environments translates to a smaller production; and to focus in on how the spatial language of these tech-demos navigates the promise of variability inherent to virtual production within the limitations of staging a whole scene in front of what is essentially, an enormous television.

The first example, "The Cube," comes from a company called Enginious (2022) and tells the story of a man who briefly meets a woman in an airport lounge who then leaves behind an obscure cube. When handled this cube transports the man away from the airport lounge into a variety of dis-contiguous environments: a futuristic city scape populated with holograms; a desert scene; a jungle; a stage inside an LED volume with an indicative virtual production set up; and finally, back to the airport lounge. The spatial language of the film is concerned with establishing the worlds in which the man finds himself. In each instance, the actor is framed in the fore- or middle ground with a highly detailed backdrop behind him. The disjunctive jumps between spaces and environments occur without an edit, the man fiddles with the cube and space around him glitches and transforms. The continuity of his physical presence within the space(s) is secured by the interactive lighting that plays on his face as he is transported and looks around in wonder. Each environment casts a particular hue of light over his skin and costume: green for the jungle, blue for the snow-swept landscape, bleached for desert environment, and so on. The variability of the environment is celebrated through the disjunctive changes of lighting and the performer's reactions in a film that is otherwise restricted to simple compositions with the camera and performer and the background evenly spaced. This is vital to my argument: whilst the mise-en-scène changes, spatial compositions do not.

An obscure cube features prominently in a similar tech-demo virtual production short called "Imagine" by Co-Pilot studios (2021), a similarly scaled VFX vendor to Enginious, although in this instance based in North America. Here the film follows a young girl who is transported out of her plain bedroom environment to a desert where she discovers a

mysterious blue cube. After some manipulation of the cube, the environment around her changes into a lush forest, while a voice-over in the background extols the power of the imagination of children and prompts the viewer to "imagine a place where ideas come to life in an instant." Hearing a noise, the girl runs back to her bed which is present in the lush forest environment. Once again, interactive lighting is important to the illusion that the girl (and her bed) is physically present in the improbable landscapes that surround her, as are spatial compositions that give prominence to this lighting and its reflections on the girl's skin and hair. As with "The Cube," the spatial compositions are relatively simple and minimise any movement of the actors within the space. The environments around them filmed as In-Camera VFX are just that, merely environments and not sets. Action doesn't happen within them; their reconfiguration is the action.

What is important to take from these demonstrative films is firstly the limited range of spatial compositions that the virtual production set up allows, a limitation that is nested within a rhetoric of infinite possibility. The tension between these two characteristic features is at the heart of the virtual production practice and aesthetic, but also a key component in understanding softwarization. The spatial fantasy of infinite reconfigurability articulated by these early examples of virtual production is entirely enabled by the complex software architecture of Unreal, and its various virtual production specific plug-ins, all of which quantify phenomena in space in a variety of ways in order to synchronise the physical and cinematographic space with the virtual and data-driven one. Given how complex the process is and how labour intensive the software management required to achieve these effects is, in the case of small-scale projects there are clear parameters on the modes of cinematographic spatial expression available to the film-makers. Whilst the environments demonstrate a modularity in excess of any other mode of film-making, and one that is anchored by accurate parallax, detailed reflections and interactive lighting, the spatial language that occurs within that modularity is limited. The software prioritises modularity and variability over nuanced spatial expression. Just as Technicolor amped up the red in its "demonstrative" mode of colour design, so the spatial language of "demonstrative" virtual productions celebrates the variability of its wrap-around environments and anchors its rhetoric of imaginative transformations in a sober compositional language of mid-shots, with performer's bodies hovering in the middle-ground between busy foregrounds and detached backgrounds.

Higgins summarises the "restrained mode" of colour design as motivated by the market imperative that colour film prove its utility within popular genres and popular modes of cinematic realism. In short, early Technicolor films like the outdoorsy romance *The Trail of the Lonesome Pine* (1936) catered to, rather than disrupted, the normative generic appetites of the cinema-going audience. Whilst colour would come to re-define the expressive potentials of certain genres (such as in Douglas Sirk's melodramas), in the "restrained mode" the colour design emphasized Technicolor's utility within pre-established genres. With this in mind, in order to historicize the "restrained" mode of the spatial language of virtual production it is worth looking at its deployment within contemporary big-budget action cinema. In these productions Unreal Engine and the virtual production pipeline are part of a suite of visual-technological solutions. As such we can anticipate that the aesthetics particular to virtual production will not be as prominent. However, this is not to say that virtual production's modularization of spaces and reconfiguration of 3D environments is not legible. Instead, many of the spatial characteristics of actions cinema are, as we shall see, incorporated within the spatial affordances of virtual production and the functionality of its core software.[2]

Red Notice (2021), *Bullet Train* (2022), and *The Batman* (2022) all contain passages produced on LED stages using virtual production techniques reliant on Unreal Engine software. *Red Notice* (2021) is a globe-trotting narrative which features a variety of vehicular-based sequences—on a train and on a helicopter, notably—where the rushing backgrounds and interactive lighting are provided by LED screens. *Bullet Train* (2022) perhaps building on the way that Red Notice successfully used VP in its "travelling action" sequences, takes place almost entirely within a moving train, with the background dynamism and environmental features rendered onto an LED-wall outside the physically constructed train set. The immersive lighting that VP affords plays a noticeable role in *The Batman*, particularly the scenes set in the skeletal upper floors of a high-rise building. The location offers extensive views of Gotham during the golden hour, with a plethora of reflections and soft diffuse lighting effects playing off the costumes of the characters. As such it is typical of the spatial language of virtual production: a clear geographical distinction between foreground and background hides the seam between physical set and LED wall, whilst over-

[2] As with the early R&D of VP in highly capitalised productions and the development of Unreal's Roadmap, there is another story to be told here about the parallel evolution of the spatial languages of large-scale action cinema and the chief offerings of Unreal Engine's Virtual production suite (it is worth, for instance, comparing the 2019 "Handbook" and the 2022 "Handbook" to see how integral to Epic's framing of VP the achievements highly capitalized collaborations with Netflix have become).

cast dramatic lighting interacts with the surfaces of the physical set producing the illusion of a never-ending dawn high above a murky metropolis.

VP processes can integrate into larger production pipelines. As the restrained use of virtual production throughout these high-profile films makes clear, the modularization and re-programmability of space inherent to virtual production's software dependent practice enables it to solve particular production problems in a modular fashion. But this is not to say that this restrained use of VP doesn't have a visual signature. Without exception, the spaces in these films are made rich with golden hour lighting, which has a distinct effect on the spatial aesthetics. The editing skips between wide-angle shots and close-ups, so that the play of light from the dramatic skies can be glimpsed on the performer's costumes (without any complex colour grading in post). Just as Technicolor's restrained mode showed that colour cinematography could look natural, so virtual production's restrained mode shows that action can be subtly and interactively lit.

I'll now turn back to *1899*. Overall, its representation of space and its thematization of the modularity and reconfigurability of space within 'the simulation' makes it worth singling out as a notable expressive use of the logistical and aesthetic characteristics of virtual production. Higgins' notion of the "integrative mode" of colour design within mature Technicolor productions applies to the spatial aesthetics of *1899* because the technical affordances of the new technology are key to the expressive features of the piece. Just as (stretching the analogy) *Gone With The Wind'*s hues fluctuate in harmony with the narrative's emotional intensity, so the spatial language of the show illustrates its central conceit, and the reconfigurations and modularisations of space deepen and multiply as the show's plot moves forward.

This is particularly acute as the narrative reaches its crescendo, and the internal consistencies of the simulated world that the characters are trapped inside begin to disintegrate. For example, in the penultimate episode (Episode 7: "Storm"), Daniel (Anuerin Barnard) pursues Maura across a range of landscapes travelling between the wildly discontiguous spaces through tunnels draped with wiring, pipes and tubes. He emerges from a porthole resembling a submarine hatch into a snowy landscape and as he does so the background around him starts to twitch and flicker. Another porthole glitches in and out of visibility and Daniel walks toward it with his arms outstretched. His hands discover something solid, seemingly in thin

air. He claws away at the space in front of him, releasing a circular panel which reveals a dark hole in the middle of open space. This strongly signals the logistics of virtual production filming in front of LED walls and indeed makes a feature of the fact that all the locations in the show are a combination of physical space and digital environments displayed within an LED volume. Using Higgins' rubric, we can identify this unfolding of a spatial language that highlights the paradoxical adjacency of discontiguous spaces, as asserting the spectacular affordances of a new production technology whilst also remaining in dialogue with the generic and aesthetic expectations of the wider visual culture. This completes the analogy to Higgins' analysis of Technicolor and gives us various tools with which to anticipate how screen spaces will be managed in the era of virtual production and Unreal Engine. Expressive spatial compositions can be approached from two angles, firstly querying how the image was staged against an LED wall in order to account for the compositions themselves, and secondly, analysing to what degree the parameters of the software-dependent process are present as determining factors within the frame and its spatial aesthetic.

With these two analytical strategies in mind, I would now like broaden my discussion in this final piece of analysis and look at how the software spaces of *1899* reflect and refract the softwarized spaces of our own experience. I'll proceed via aesthetic analysis premised on the idea that these images 'emblematize' not only the conditions of their production, but the wider technological and epistemic contexts in which they were produced.

There are two things that are worth noting in this same sequence from Episode 7 of *1899*. The first is that the shot in which Daniel appears to peel a panel away from the LED wall could not have been achieved in-camera, and therefore has not been wholly driven by the Unreal Engine. Indeed, it was achieved via a traditional VFX pipeline: a green-screened prop tunnel was placed in the volume. Secondly, as is clear from Daniel's manhandling of the edges of the illusory spaces he finds himself in, and his repeated crawling through pipes jam-packed with tubing, the simulation at the heart of *1899* is one that is sustained and mediated by hardware. This is underwritten not just in the way that Daniel claws at seemingly empty space until a panel peels away from his environment, but also in how the sequence's soundtrack supports this intuition of the machine underlying reality, saturated as it is with metallic scrapes and clangs. Seen in this way, this brief sequence extends a tendency, seen across visual culture to highlight the material and the mechanical, whilst obscuring the calculative the computational and the algorithmic. Speaking in terms of softwarization, this

sequence *under-emphasizes* both the role of software in the expression of our technological imaginary and the role of software in the generation of the spatial experience. In this closing section I'll suggest that this extends to the spatial experience of both the characters within the show and the audiences experiencing the show via screens and networked devices.

As I widen my perspective from the spatial language of virtual production to the wider aspects of the softwarization of modes of spatial representation (and ultimately, space itself) this de-emphasis on the mediating force of software, as opposed to hardware, will become crucial. Within visual culture, and especially VFX-intensive visual culture where production pipelines are reliant on multiple interconnected software packages, there is a consistent emphasis on the materiality of hardware over the invisible intricacies of software. Extending this tendency, the production of *1899* relied extensively on the Unreal Engine 5.0 and yet, by design or by default, software as a vital component in the mediation between data and embodiment—in the generation of the show's "simulation"—is profoundly absent. Characters flick switches and tug wires, as they travel between incompatible spaces, but they never reconfigure an API. Yet, despite this representational and thematic elision: software has never been so integral to the generation (simulation) of spatial illusions and onscreen spatial experience as it is in virtual production. This is more than a theoretical or media-epistemological conceit. A behind the scenes documentary produced by Netflix ("Into the Volume: A Behind-the-Scenes Look into the Virtual Production of 1899," 2023) is full of first-hand testimony to how the experience of the LED volume impacted the actor's embodied experience and their performances. One typical claim is that the actors are "transported." At the very least, a consideration of virtual production from the point of view of performance studies and performance practice would be a valuable contribution to our understanding of this transforming production culture.

Ultimately, the disavowal of software in *1899* (and its ilk) reveals a deeper problematic within computational culture with regards to the legibility of software and its epistemic influences. The centrality of software to cultural production is inversely correlated to its presence within visual culture; the more software shapes how we see, the less visible it becomes. Manovich, at what must have felt at the time to be something close to the apotheosis of computational culture, wrote contra Kittler's claim that "there is no software" (Kittler 1999), that "there is only software" (Manovich 2013). Riffing on Manovich and Kittler, Kaldrack and Leeker declare that "there is no software, there are just services,"

(Kladrack and Leeker 2015) a position that speaks to software's increasing recession from creative interactivity and accountability in a computational culture running on mobile devices and cloud services. Where once software could be hacked, personalised and modded, in a world of software as service, that last vestige of software tangibility, the notion of being able to intervene in the code-bed that governs the conditions of mediation, has disappeared.

This is why the emergent practice of virtual production offers such a good opportunity to re-connect aesthetic analysis and critiques of softwarization. Unreal Engine governs the appearances of these images even as it escapes from view. By building a concrete perspective on the aesthetic fallout of one ascendant software regime, we can glimpse the interrelations between other aspects of experience and the wider social and cultural process of softwarization. Spatial experience on screen is softwarized, but by picking it apart as it undergoes an industrial and aesthetic inflection it might be possible to reveal the role of softwarization in the aestheticization and governance of other aspects of lived experience.

Tearing a panel from the wall, Daniel uncovers the techno-material conditions of the simulation of space he's standing in, in a manner that applies to both the narrative milieu of *1899* and the production milieu of virtual production. However, sublimated within this very image is the fact that the conditions of virtual production and ICVFX cannot allow for this extended and tangible interaction with the projected environment and the LED wall, not least because LED panels are expensive. Moreover, the proximity of the camera to the LED wall would disintegrate the illusion of spatial continuity between physical stage and digital environment. Even with the frustrum correlating the spatial parallax between the camera, the performer and the background, the pixel pitch on the panels would be visible and pronounced aliasing on the digital assets, across all mid- to deep background spatial fields, could occur. In short, the scene representing a character physically transcending the spatial parameters of the "simulation" serves to indicate the computational parameters that determine the representation of space in a virtual production environment. And, as mentioned, given that the shot could not have been achieved in-camera, it also delimits the core affordances of virtual production. Consistent across all the examples discussed so far, the primary spatial effect of VP is the reconfiguration of digital environments around the volume, and the primary impact of this mode of production as it rises to ubiquity will be in emphasizing, not the interconnectedness of discontinuous spaces, but the modularity of spatial experience itself. This shot is the exception that demonstrates the norm. The giving over of space to

software doesn't empower the individual to hack space, but rather renders all spatial experience modular and reprogrammable within the affordances of the software.

In conclusion, I would like to extrapolate on what has been discussed in this chapter and ask how the ubiquity of virtual production and its emergent language of modularised space might impact our own embodied experiences of space beyond screen experience. Here again, the key factor is the softwarization. If virtual production allows us to glimpse the new aesthetic norms of a production where Unreal Engine stands as the principal determinant in the representation of space onscreen, does the increasing role of software in our spatial experience, for example in our experience of geographical orientation or urban navigability, come with an analogous set of experiential norms? Further, what can the link between softwarization and modularisation in virtual production teach us about the embodied experience of software dependent environments? To what degree can the aesthetics of a fully softwarized production process like virtual production alert us to the experiential qualities of software-dependent existence? The tropes of virtual production promote a version of spatial experience defined by the reconfigurability of our environments and an embodied experience that responds positively to the spectacle of totally modularised space. But the question remains as to whether this fantasy of re-programmable space is one that is fulfilled in software's influence over our everyday spatial experience. Put differently, is *1899's* spatial language engaged in normalising a more insidious re-making of space under the influence of software?

I'd suggest so. Over the past few years, our experience of urban environments has been increasingly overturned by the software interfaces of last-mile logistics and instant delivery platforms, such as Deliveroo and Getir. This dynamic accelerated with the 2020–21 lockdowns, which translated the privileges of urban experience—the convenience and accessibility of restaurants, for example—into a software dependent experience. This in turn led to the phenomenon of "dark stores" and "ghost kitchens," which are real spaces that aren't contiguous with the embodied experience of the city, but that have been configured according to the infrastructural demands of the delivery platform. Shapiro, in his analysis of "platform urbanism" (Shapiro 2022) argues that the business models of these delivery platforms "cognize space through the discourse of software and platform economics," and resultingly enforce the re-configurability of physical space across all scales—from the individual store, to the neighbourhood, to the urban sprawl at large—to enhance the

functionality of last-mile logistics software. Shapiro argues that this is a platformization of urban space driven by the functionality of last-mile logistics software, and that ultimately those spaces and environments that aren't platform-ready will suffer exclusion from the convenience economy.

This is the distant horizon of the softwarization of space; nevertheless, it is one foreshadowed within the spatial aesthetics of a show like *1899*. Here, the contradictions between the promises of the infinite reconfigurability of the environment and the narrow ways in which space itself can be represented, can be taken as emblematic of a larger relationship between spatial experience and software that is growing in fields beyond screen studies. Analysing the particularities of a virtual production's representations of space with a view of the myriad software-dependencies that are entailed gives access to some of the hidden technical defaults of the technology. Given the proximity of virtual production, and software intensive processes like it, to passing a "vanishing point" and becoming naturalized parts of our visual experience, this work of highlighting the tensions and distinctions of this emergent mode of spatial representation takes on a degree of urgency. If the spatial compositions characteristic of virtual production exert a normative force on visual culture more broadly, then their framing of space as infinitely reconfigurable will take on an epistemic weight. virtual production spaces, like the standardisation of time in cinematography, and the three-strip colour processes of Technicolor before it, will have a "knowledge effect," and our embodied experience of space will become something always-already softwarized.

References

Bennett, J., Heath, C., Kilkelly, F., & Richardson, P. (2021). Virtual production: A global innovation opportunity for the UK. StoryFutures Academy

Buolamwini, J. (2020). *The coded gaze: Bias in AI.* Youtube [Online lecture]. Retrieved from https://www.youtube.com/watch?v=rjesnx_Pp5w

Chun, W. H. K. (2011). *Programmed visions: Software and memory.* Cambridge: MIT Press

Co-Pilot (Prod.). (2021). *Imagine*. Youtube [Online video]. Retrieved from https://www.youtube.com/watch?v=k9V5YRn_ssg

Corrigan, L. (Dir.). (1934). *La cucaracha.* USA: Pioneer Pictures

Doane, M. A. (2002). *The emergence of cinematic time: Modernity, contingency, the archive.* Harvard University Press

Enginious. (Prod.). Szczepański, P. (Dir.). (2020). *The cube.* Vimeo [Online video]. Retrieved from https://vimeo.com/472508754

Epic Games. (2019/2022). The virtual production field guide. Retrieved from https://www.unrealengine.com/en-US/blog/volume-2-of-the-virtual-production-field-guide-now-available

Epic Games. (Prod.). (2022). Brain Bar, or whatever we're calling it these days. Unreal Fest 2022 Presentation. Youtube [Online video]. Retrieved from https://www.youtube.com/watch?v=fkHdZl4z-Jk&t=35s

Favreau J. (Dir.). (2019). *The Mandalorian.* Disney

Fleming, V. (Dir.). Selznick, O. (Prod.). (1939). *Gone with the wind*. USA: MGM

Freeman, E. (2020). *The persistence of code in game engine culture.* Routledge

Hathaway, H. (Dir.). (1936). *The trail of the lonesome pine*. USA: Walter Wagner Productions

Higgins, S. (2007). *Harnessing the technicolor rainbow: Color design in the 1930s.* University of Texas Press

Jungherr, A., & Schlarb, D. B. (2022). The extended reach of game engine companies: How companies like Epic Games and Unity Technologies provide platforms for extended reality applications and the metaverse. *Social Media + Society*, 8(2), 20563051221103110

Kittler, F. (2014). There is no software. In F. A. Kittler (Ed.), *The truth of the technological world: Essays on the genealogy of presence*. Stanford University Press, 13-31

Kladrack, I., & Leeker, M. (Eds.). (2015). *There is no software, there are just services.* Meson Press. Retrieved from https://meson.press/books/there-is-no-software-there-are-just-services/

Leitch, D. (Dir.). (2022). *Bullet train.* Sony Pictures

Lewis, S. (2019, April 25). The racial bias built into photography. *The New York Times.* https://www.nytimes.com/2019/04/25/lens/sarah-lewis-racial-bias-photography.html

Mamoulian, R. (Dir.). (1935). *Becky Sharp.* Pioneer Pictures

Manovich, L. (2015). *Software takes command.* Bloomsbury

Misek, R. (2010). *Chromatic cinema: A history of screen colour.* Wiley-Blackwell

Netflix Production Technology Resources. (Prod.). (2023). *Into the volume: A behind-the-scenes look into the virtual production of 1899*. Youtube [Online video]. Retrieved from https://youtu.be/ZMynJCgJIQk

Odar, B. B. (Dir.). (2022). *1899*. Netflix

Reeves, M. (Dir.). (2022). *The Batman.* DC Films

Shapiro, A. (2022). Platform urbanism in a pandemic: Dark stores, ghost kitchens and the logistical-urban frontier. *Journal of Consumer Culture*, 22(1), 1-20 https://doi.org/10.1177/14695405211077184

Thurber, R. M. (Dir.). (2021). *Red notice*. Netflix

Wellman, W. (Dir.). (1937). *A star is born*. USA: Selznick International Pictures

Whissel, K. (2014). *Spectacular digital effects: CGI and contemporary cinema*. Duke University Press

Zielinski, S. (1999). *Audiovisions: Cinema and television as entr'actes in history.* Amsterdam University Press